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The Importance of Exercise and Nutrition in Early Life

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Arkansas Children's Research Institute | Nutrition Center

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The importance of exercise and nutrition in early life

Elisabet Børsheim, Ph.D.

September 13, 2021

Career path

Strandebarm, Norway

Ex. Phil, Natural Sciences;
University of Bergen

Career path

NORWEGIAN SCHOOL OF SPORT SCIENCES

BSc - Exercise Sciences

University of Oslo
BSc - Natural Sciences
MSc - General Physiology

NORWEGIAN SCHOOL OF SPORT SCIENCES

Collab. with the National Institute of Occupational Health, Norway
& Sahlgren's Hospital, Sweden

PhD – Human Physiology

Career path

Shriners Hospitals for Children™

utmb Health

Working together to work wonders.™

Postdoctoral fellow. Mentor: Robert R. Wolfe

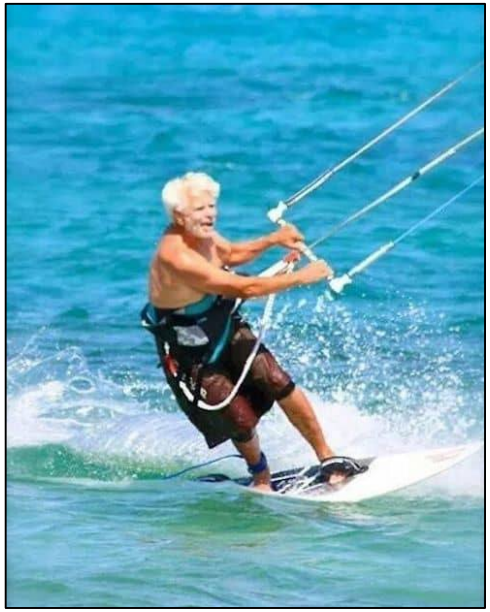
Stable isotope methodology, muscle protein metabolism

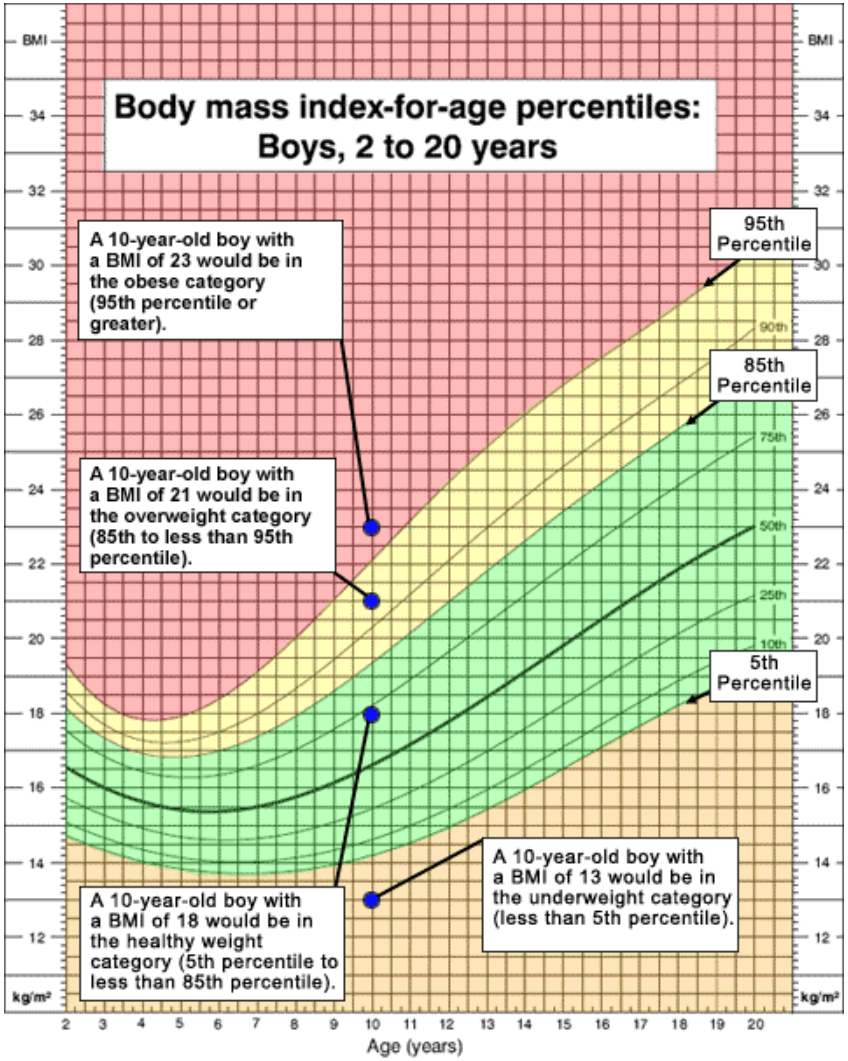
Physical Activity, Energetics and Metabolism (PAEM)

- Arkansas Children's Nutrition Center, Arkansas Children's Research Institute
- Physical activity facility for controlled exercise training
- **"Laboratory for Active Kids and Families"** for fitness and pulmonary testing

Wet Lab & equipment for high resolution respirometry and mass spec technology

Life Span - Health Span





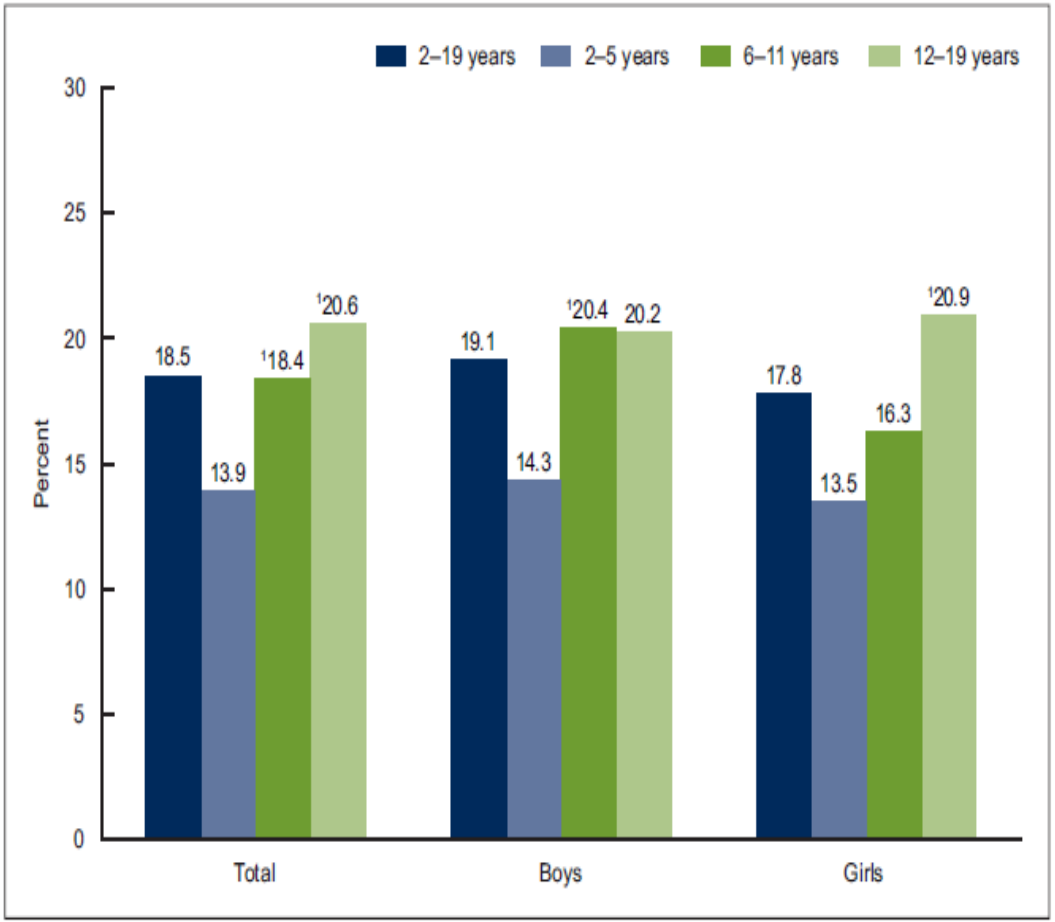
Definition of Pediatric Overweight and Obesity

BMI percentiles for age and sex an alternative to direct measures of body fat

Overweight: ≥85th and < 95th percentile
Obesity: ≥95th percentile
Normal weight: ≥5th and <85th percentile

CDC

Prevalence of Obesity among US youth, 2015-16

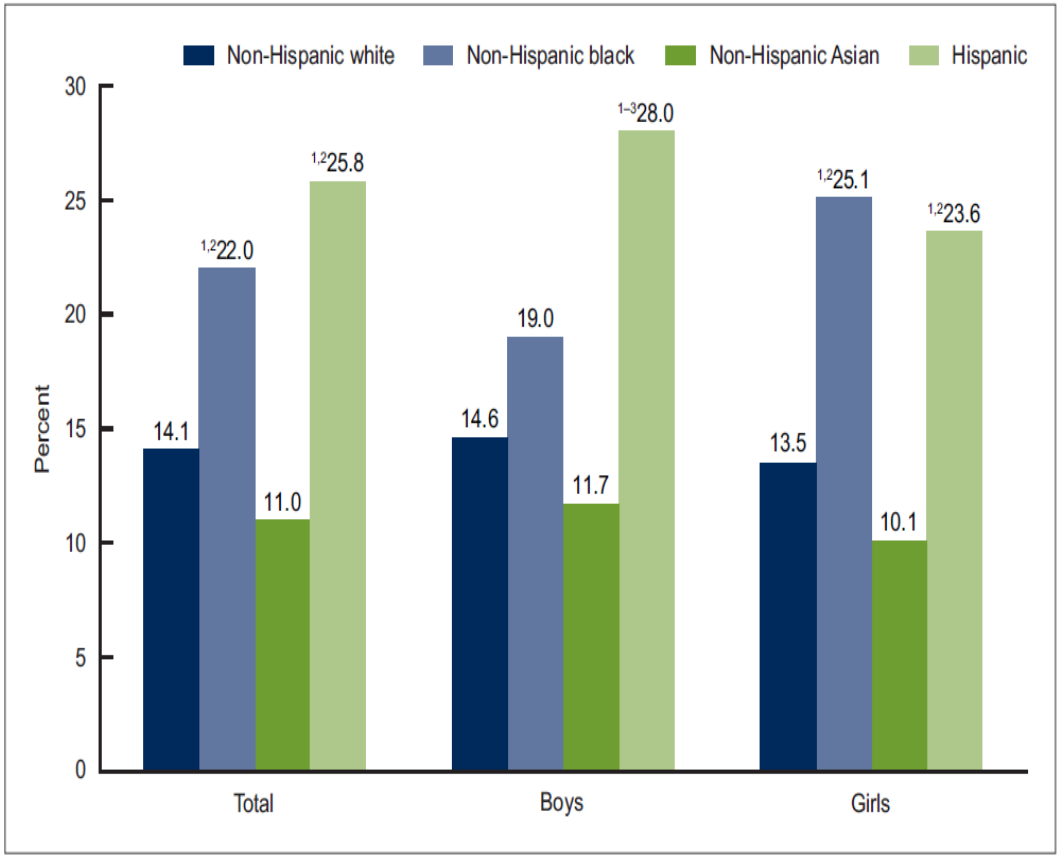


Two out of three kids are overweight or obese

18.5% obesity
16.6% overweight

NCHS Data Brief
No. 288, Oct. 2017

Prevalence of Obesity among US youth, 2015-16



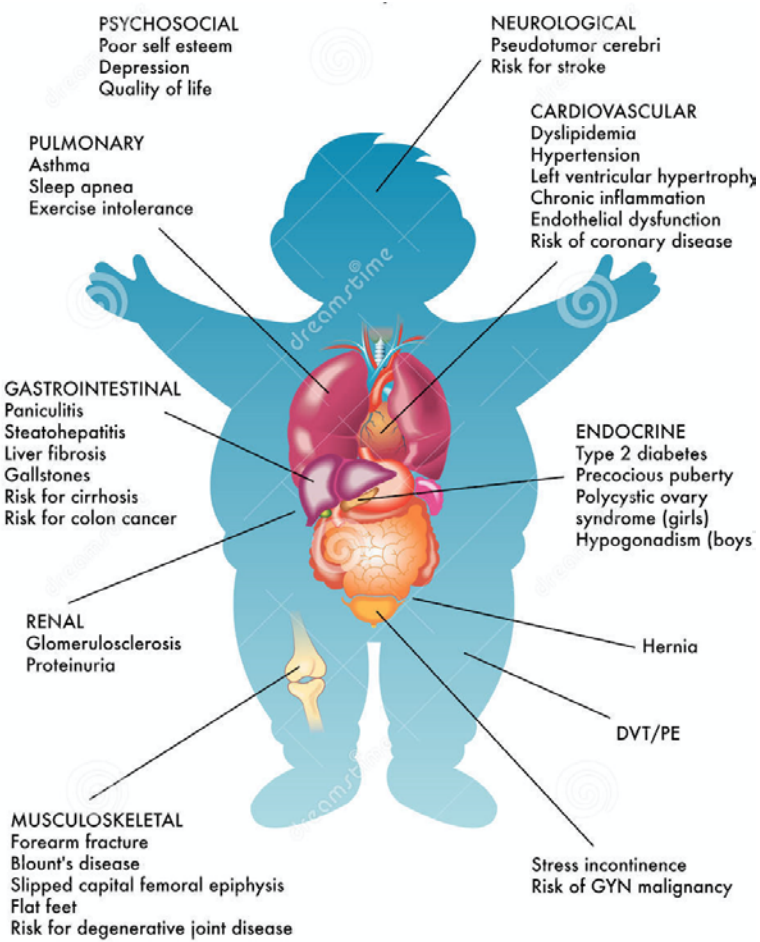
Higher prevalence in Non-Hispanic Black and Hispanic.

NCHS Data Brief
No. 288, Oct. 2017

Medical Complications of Pediatric Obesity

Childhood metabolic complications predict adulthood metabolic problems.

E.g., Magnussen et al, J. Pediatr, 2016



Childhood Obesity

- Excess weight in childhood predicts overweight in adulthood.
- Overweight at 2 years of life increases risk of overweight later in life.

- Childhood obesity a primary driver for adult cardiometabolic risk.

Chung *et al*. Ann.NY Acad. Sci. 2018

Freedman *et al*. Pediatrics 2001

Programming of Obesity

- High maternal weight gain between pregnancies increases risk of overweight in offspring compared to their siblings.

  Villamor, Lancet, 2006

- Decreased risk of obesity in children born to obese women following weight loss after bariatric surgery.

  Kral *et al*. Pediatrics, 2006. Smith *et al.* JCEM, 2009

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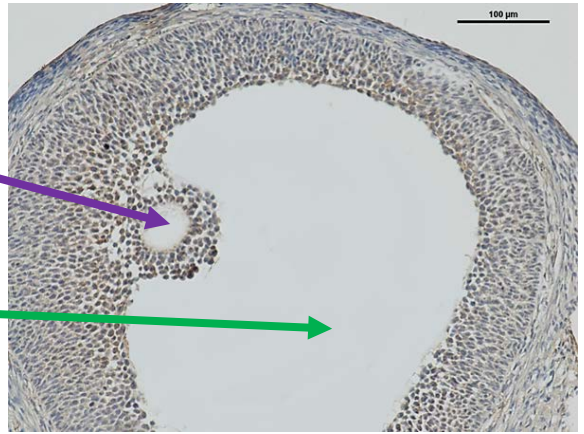
Pre-conception factors

- Oocyte and follicular fluid of women undergoing fertility treatments show differential:

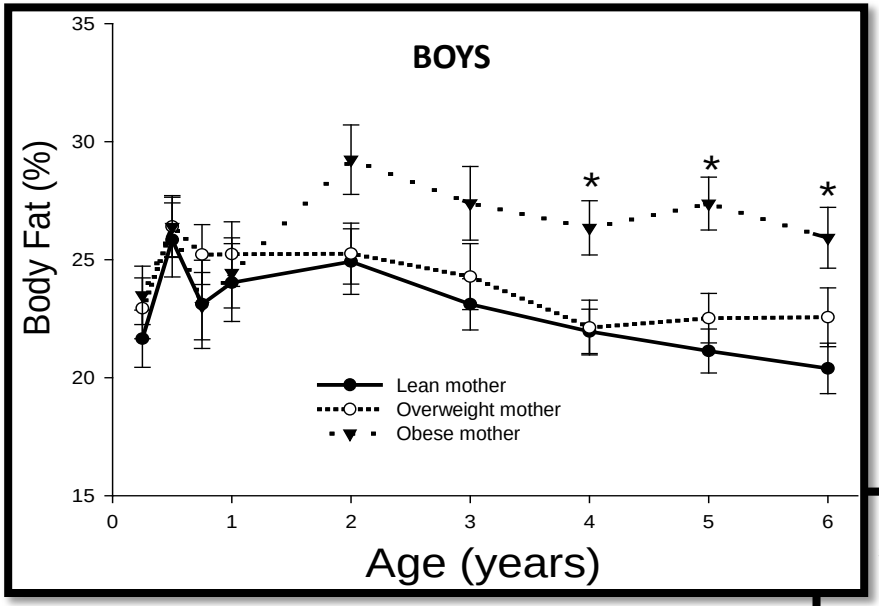
Oocyte gene expression

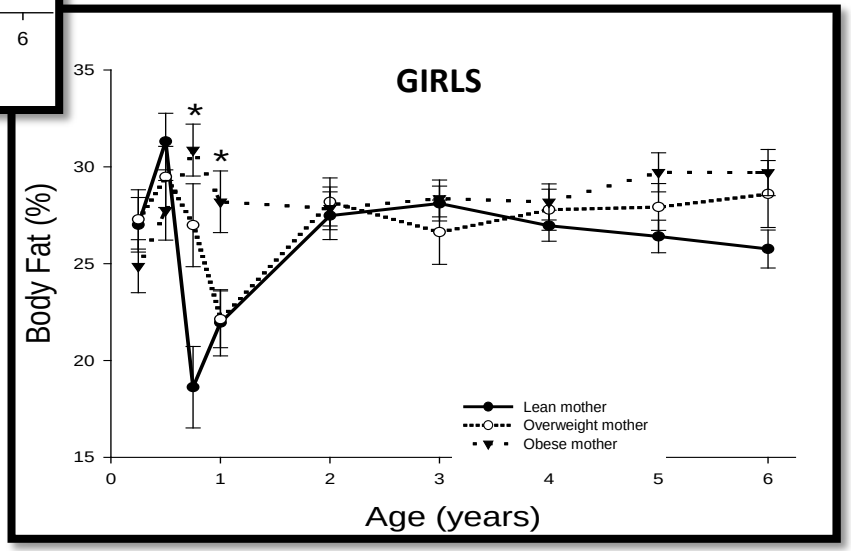
Follicular fluid metabolome



- Greater expression of pro-inflammatory genes before conception in overweight/obese women vs. normal weight

Ruebel et al. AJP Endo Met. 2019
Ruebel et al. JCEM. 2017
Ruebel et al. AJP Endo Met. 2016





Andres *et al.* Obesity. 2015

Perinatal Environment

Paternal and Maternal factors
Fetal factors

Childhood OBESITY

Critical windows?

Long-term Consequences

- Obesity
- T2DM
- Cardiovascular diseases
- Blood lipids
- Fatty liver etc

Postnatal/Childhood Environment

Energy and substrate intake
Energy expenditure, physical activity

EXPECTING study

- Physical activity intervention in obese, sedentary women.
- Structured training program from 12 weeks of pregnancy to birth vs. control
- Aerobic and strength components, 3x/week.
- Submaximal fitness tests at 12 week and end of second trimester.
- Outcomes: insulin sensitivity and markers of inflammation in mothers, risk of obesity in offspring (body weight, energy expenditure, fat oxidation at 2 years of age).

Impact of Physical Activity and Sedentary Time on Metabolic Health

- Can exercise in children born to mothers with obesity attenuate the negative effects on metabolic health?
- Mostly cross-sectional studies. Some long-term studies with several years follow up.

E.g., Barnett et al *AJE*, 2010

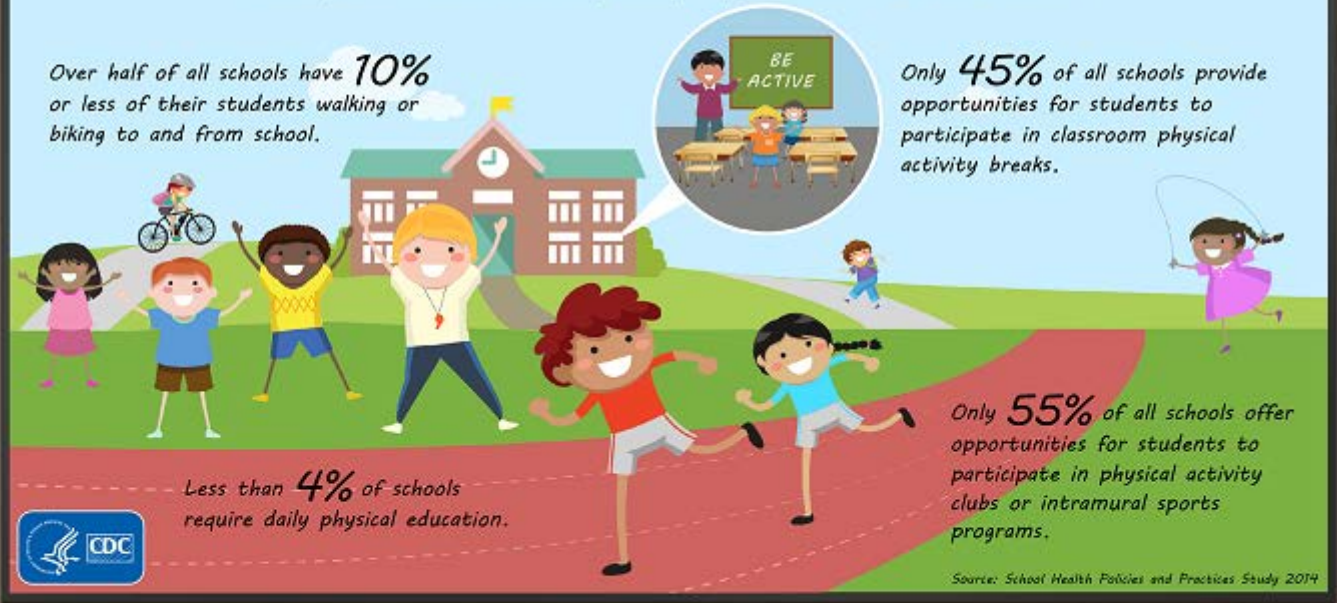
- Sedentary time vs. physical activity time.
- Moderate and vigorous activity (MVPA) of high importance.

RECOMMENDATION:

Students should do 60 minutes (1 hour) or more of physical activity daily

REALITY:

Many students are not getting opportunities to be active.



Can physical activity/fitness attenuate negative effects of obesity in children?

Arkansas Active Kids!

Arkansas Active Kids!
7-10 year old children (boys and girls)

↓

Study visit: Consent, assent, medical history, urine and saliva samples, resting energy expenditure, vital signs, DXA, blood draw, fitness test, anthropometrics, balance test, flexibility test, strength tests, questionnaires, stool sample, accelerometer

↓

Return accelerometer via pre-paid envelope or in person

ARKANSAS Active Kids!

Laboratory for Active Kids and Families

Arkansas Children's Nutrition Center

Pediatric Blood Pressure Status

- Current clinical guidelines to pediatric HBP do not consider objective measurements of cardiorespiratory fitness (CRF) to assess risk, nor CRF oriented goals to guide treatment.

Objective

Evaluate the association of peak VO_2 with blood pressure (primary outcome) and other markers of cardiovascular health in children ages 7-to-10 years.

Blood Pressure Diagnostic Categories

American Academy of Pediatrics

AAP 2017 for Children 1-13 y	
Classification	**SBP/DBP Percentile**
Normal	<90th
Elevated BP	≥90th to <95th Or 120/80 mm Hg to <95th (whichever is lower)
Stage 1 hypertension	≥95th to <95th Plus 12 mm Hg or 130/80-139/89 mm Hg (whichever is lower)
Stage 2 hypertension	≥95th Plus 12 mm Hg or ≥140/90 mm Hg (whichever is lower)

Subject characteristics

Variable	EA (n = 39)	NA (n = 172)	*p*-value
Age (years)	9.0 ± 1.3	9.0 ± 1.2	0.9722
Sex, n (%)			0.0772
-Girls	26.0 (67)	87.0 (51)	
-Boys	13.0 (33)	85.0 (49)	
BMI percentile	95.9 ± 3.0	56.5 ± 26.9	<.0001
Peak VO_2 ($ml \cdot kg^{-1} \cdot FFMI^{-1}$)	86.1 ± 19.3	97.7 ± 18.1	0.0004
FMI z-score	1.40 ± 0.25	0.04 ± 0.54	<.0001
FFMI z-score	0.93 ± 0.72	-0.23 ± 0.76	<.0001
Visceral fat area (cm^2)	51.8 ± 14.5	30.7 ± 12.0	<.0001

Subject characteristics

Variable	EA (n = 39)	NA (n = 172)	*p*-value
AC per day, 10^6	3.20 ± 0.75	3.38 ± 0.61	0.1276
Systolic BP percentile	86 ± 17	72 ± 21	<.0001
Diastolic BP percentile	78 ± 18	70 ± 18	0.006
Blood pressure status, n (%)			<.0001
-Normal	12 (30.77)	130 (75.58)	
-Elevated	9 (23.08)	20 (11.63)	
-HTN	18 (46.15)	22 (12.79)	

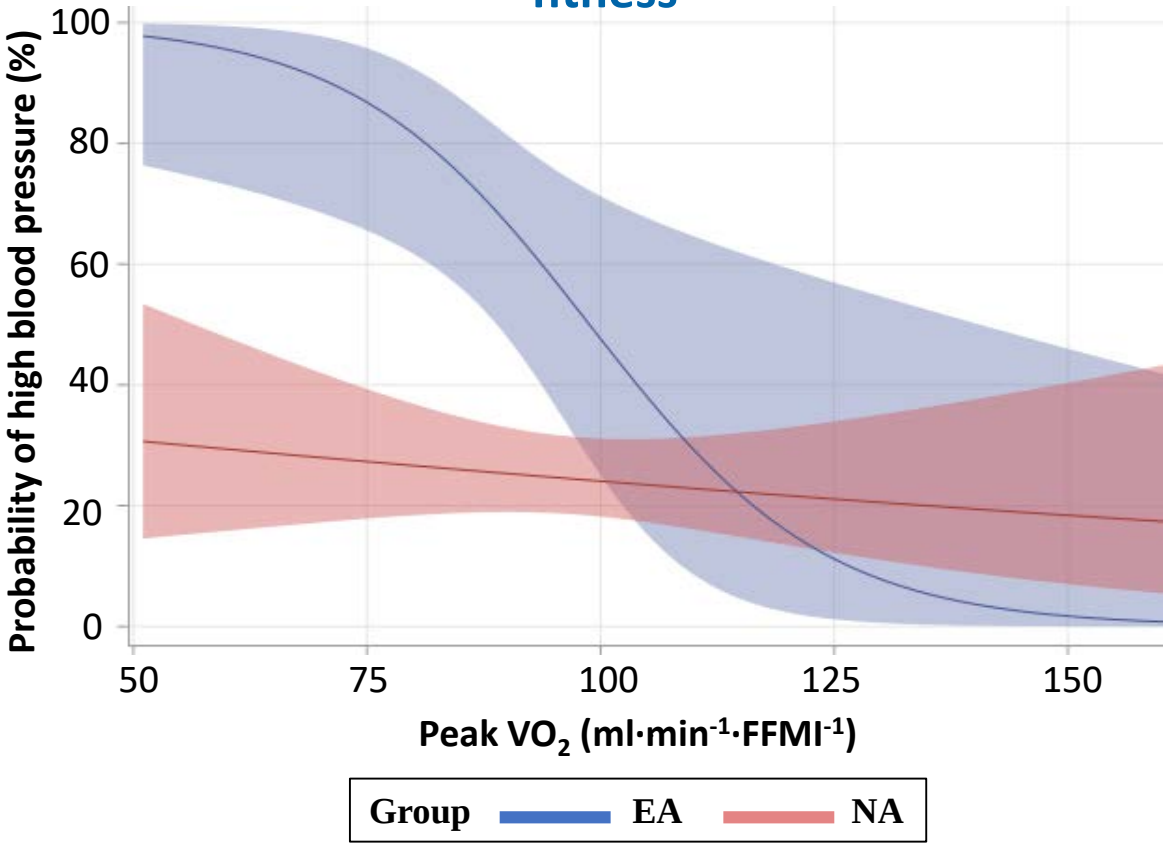
Metabolic characteristics

Variable	EA (n = 39)	NA (n = 172)	*p*-value
Insulin (pmol/L)	72.8 ± 38.7	38.5 ± 23.2	<.0001
Glucose (mmol/L)	4.8 ± 0.5	4.9 ± 0.5	0.8233
HOMA2-IR	1.3 ± 0.7	0.7 ± 0.4	<.0001
TG (mmol/L)	1.0 ± 0.7	0.7 ± 0.3	0.0095
HDL cholesterol (mmol/L)	1.5 ± 0.4	1.8 ± 0.4	0.0003
LDL cholesterol (mmol/L)	3.3 ± 0.8	2.7 ± 0.8	0.0005
CRP (mg/L)	3.7 ± 4.9	1.0 ± 2.3	<.0001

Statistical analyses

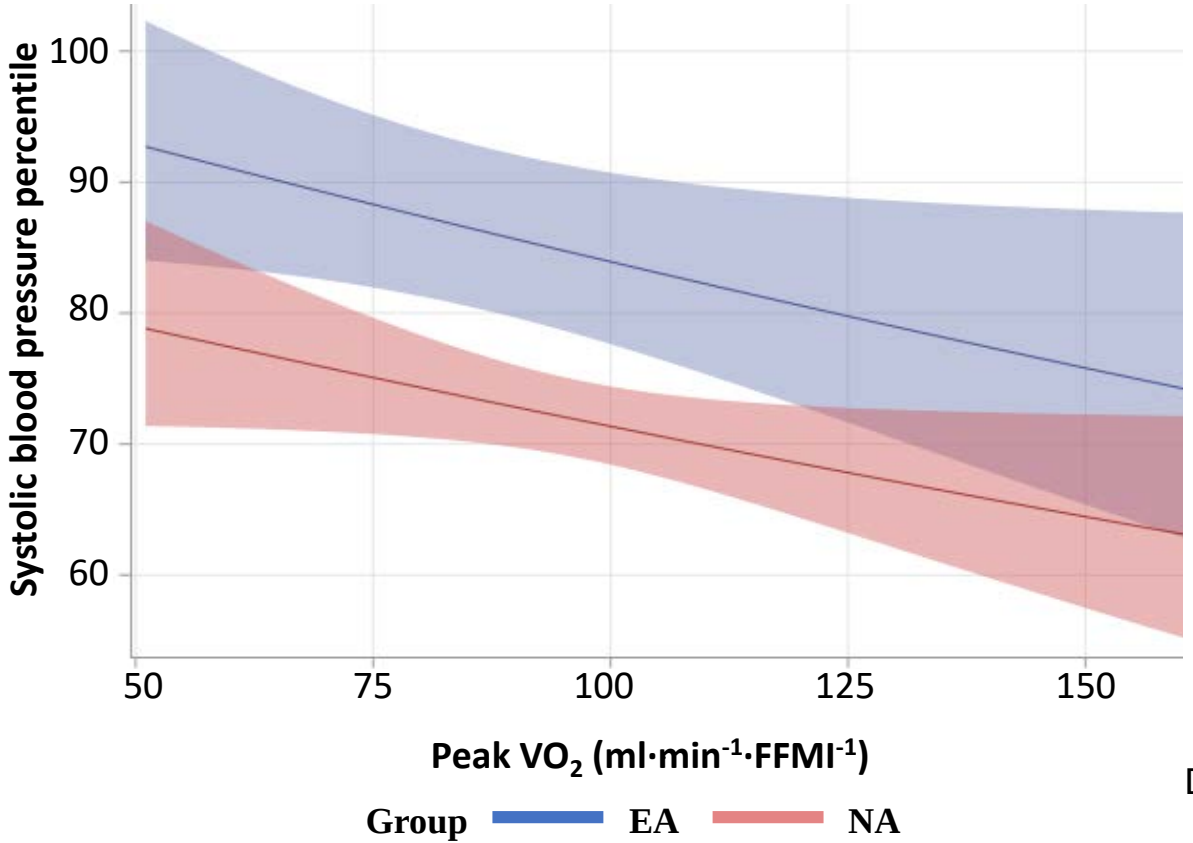
- Logistic regression analyses to model the probability of HBP in children with normal adiposity (NA) and excessive adiposity (EA).
- Simple and multiple linear regression analyses were used to model other markers of metabolic health against adiposity status and peak VO_2.

The probability of High Blood Pressure decreases with increasing fitness



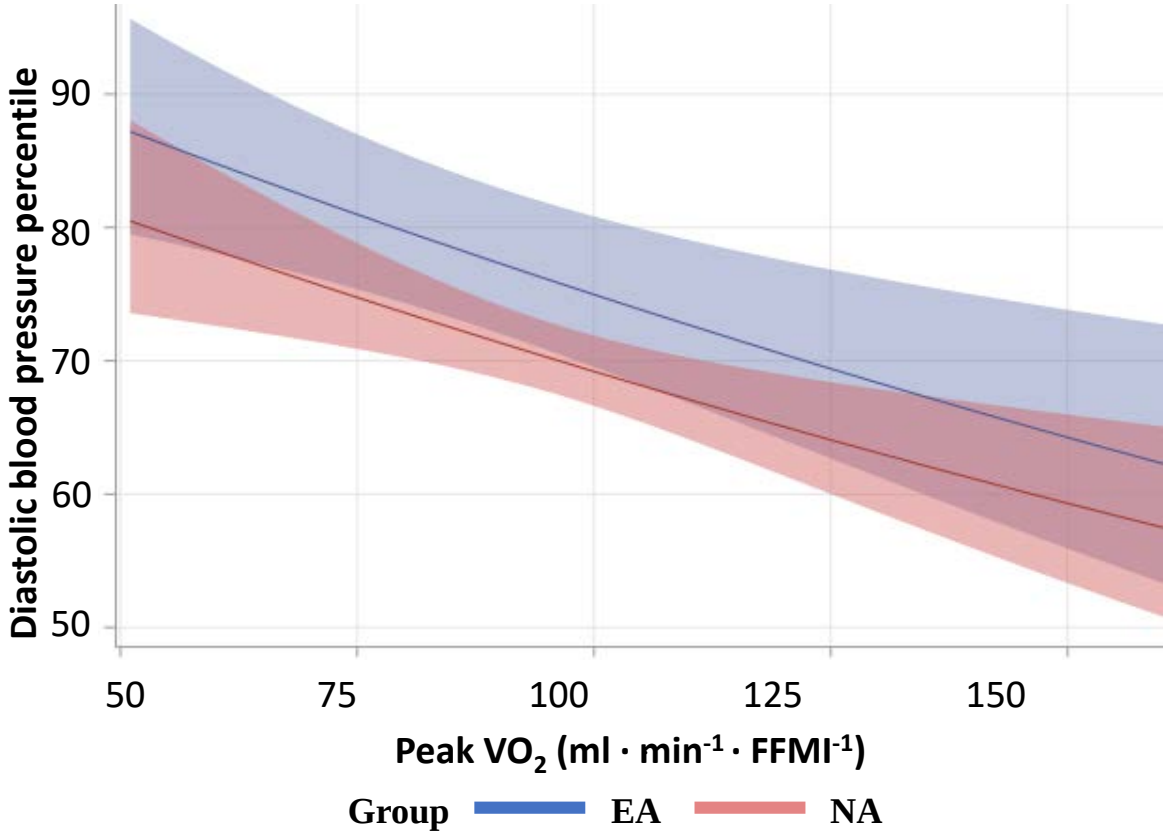
Diaz et al. MSSE 2021

Systolic blood pressure percentiles decrease with increasing peak VO_2 independently of adiposity status



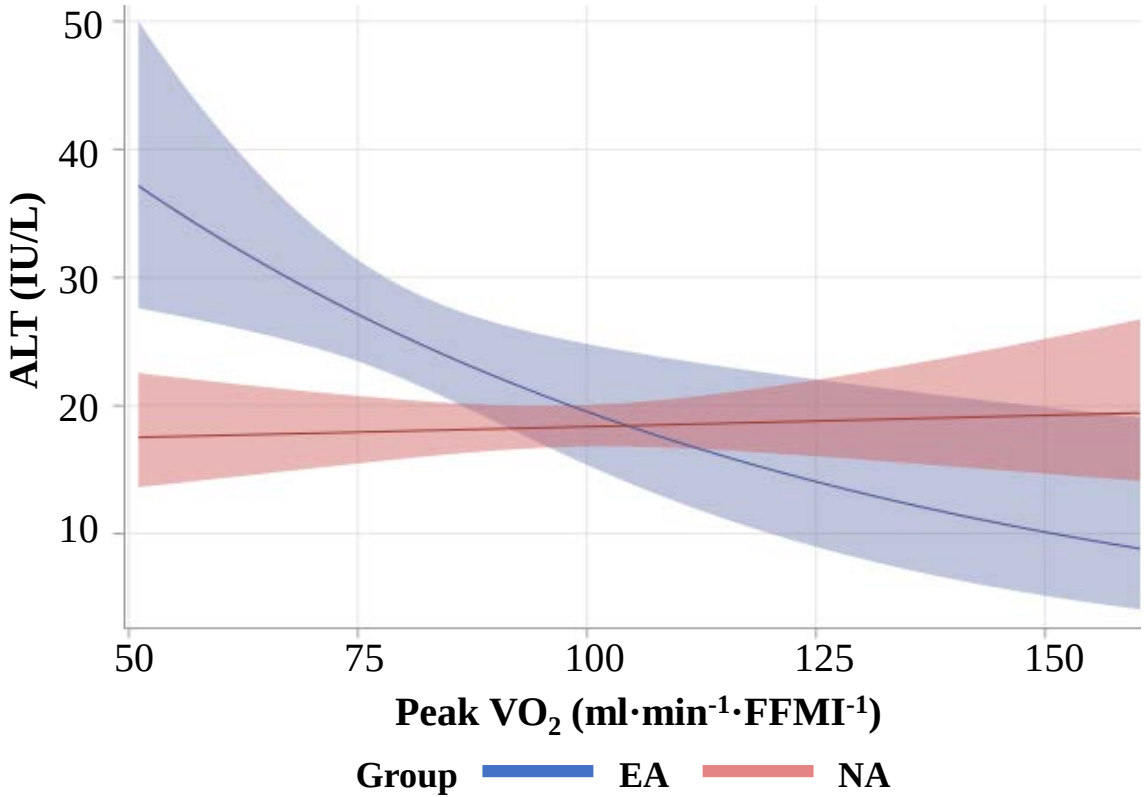
Diaz et al. MSSE 2021

Diastolic blood pressure percentiles decrease with increasing peak VO_2 independently of adiposity status



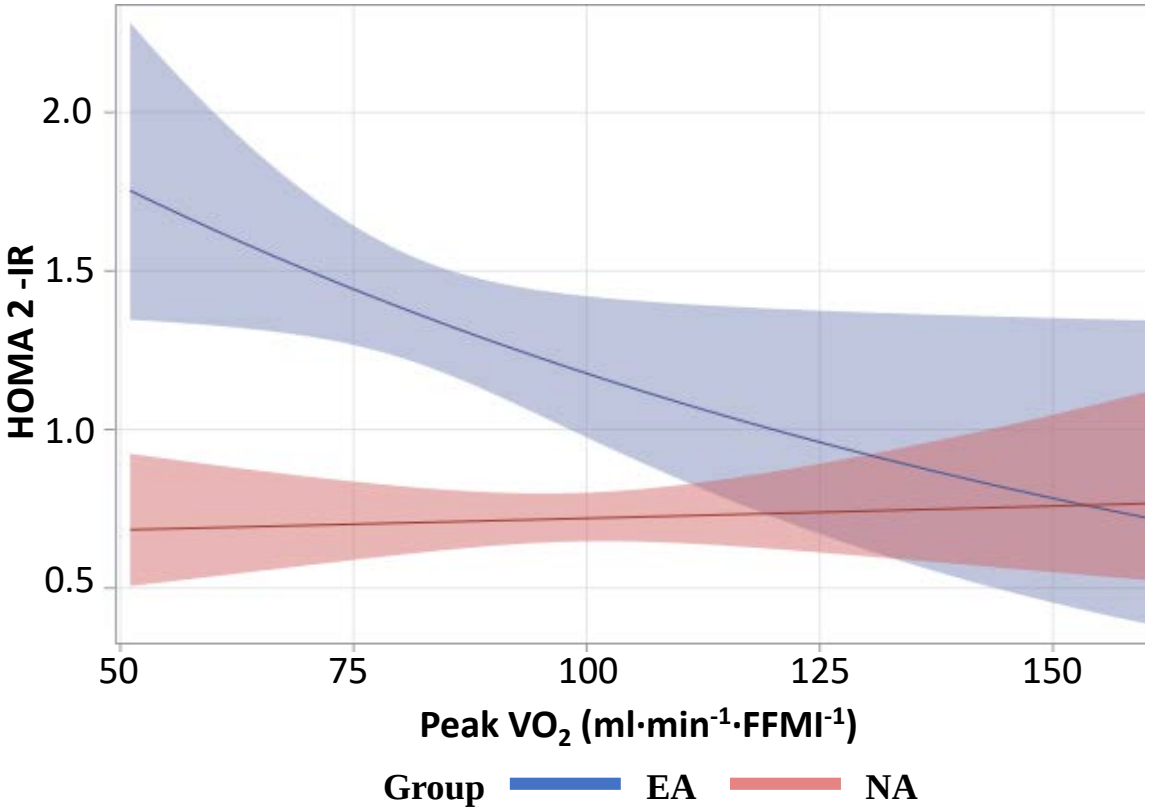
Diaz et al. MSSE 2021

Kidney function improves with increasing VO_2 peak



Diaz et al. MSSE 2021

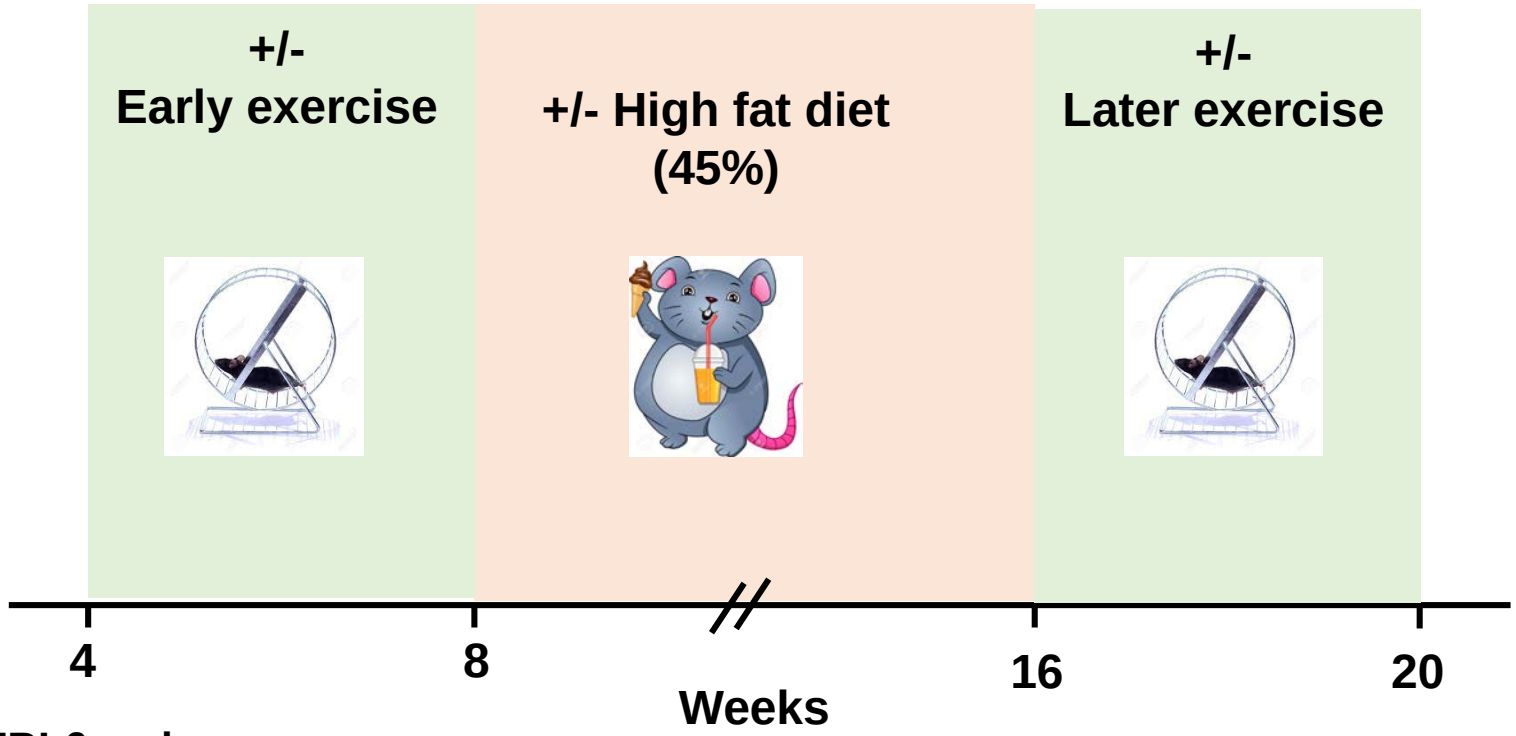
Insulin resistance improves with increasing VO_2 peak

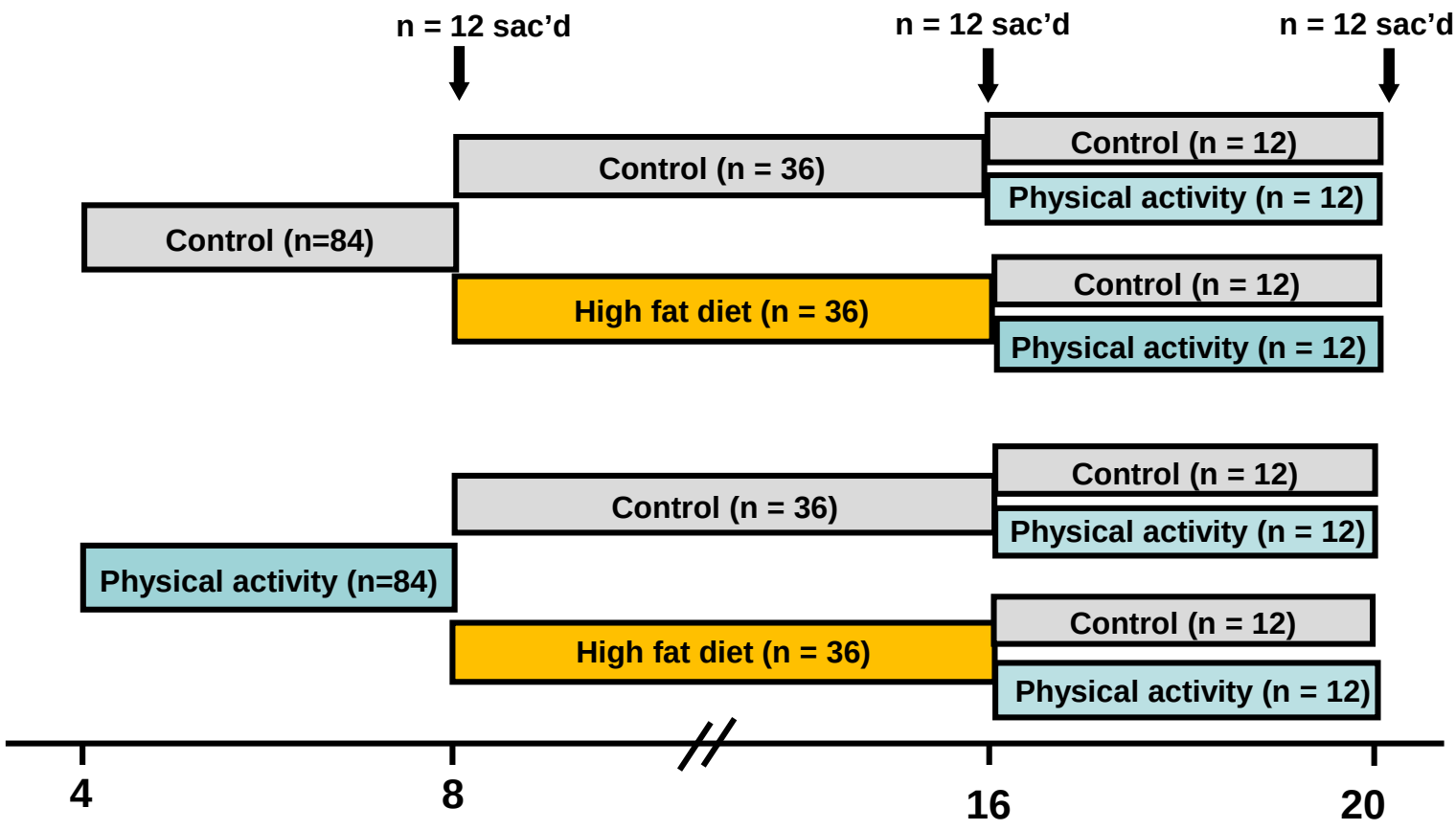


Diaz et al. MSSE 2021

Cardiorespiratory fitness impacts association between obesity and metabolic health

Early exercise – and nutrition – impact on later response to exercise and metabolic health





One Way AOV
Primary Factor: Exercise

Two Way AOV
Primary Factor: Diet
Covariate: Early Exercise

Three Way AOV
Primary Factor: Diet
Covariates: Early Exercise, Middle Diet

Early exercise - Week 4-8

Main effects PA vs. No PA

Fat mass:	-0.603 g (-1.080, -0.123), $p = 0.0139$
Avg. food intake:	0.282 g (0.0348,0.5300), $p = 0.0254$

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Diet - week 8-16

No interaction effects with early exercise.

Main effects High Fat vs. Control

Body mass: 7.49 g (5.58, 9.41), $p < 0.0001$

Fat mass: 6.00 g (4.53, 7.47), $p < 0.0001$

Lean mass: 0.84 g (-0.07, 1.74), $p = 0.0693$

Elevated Glucose AUC (GTT), Interferon γ & TNF-α in HF.

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Later exercise - Week 16-20

No interaction effects with earlier exercise and/or diet.

Main effects PA - No PA

Sac mass:	-1.510 g (-2.700, -0.323),	$p = 0.0139$
Fat mass:	-1.800 g (-2.730, -0.883),	$p = 0.0001$
Liver mass:	-0.099 g (-0.211, 0.012),	$p = 0.0815$
Insulin:	-0.276 µg/L (-0.598, 0.046),	$p = 0.0929$

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Limitations/discussion

- Equipment; lack of measurement of PA in control groups
- Design: Change of several factors at a time:
  - Continue exercise throughout diet intervention period
- Design: Short exercise period?
- Sex differences

- Effects of early exercise on
  - other outcomes, e.g., anatomy, muscle stem cells?
  - motor skills, coordination, and cognitive factors; facilitating exercise participation throughout life and thus impact metabolic health?

Summary

- Early obesity predicts later life obesity and cardiometabolic health.
- Increasing cardiorespiratory fitness may attenuate negative effects of excess weight on metabolic health in children.
- Importance of early exercise and nutrition on lifespan/health-span?
- Exercise has significant metabolic effects also if started later in life.

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Acknowledgement

- Participants
- The Clinical Core; the Physical Activity, Energetics and Metabolism Core; the Vivarium; the Biostatistics Core at the Arkansas Children's Nutrition Center
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- USDA/ARS 6026-51000-010-05S
- NIH/NIDDK R01 DK107516
- Arkansas Biosciences Institute (the major research component of the Arkansas Tobacco Settlement Proceeds Act of 2000)

USDA ARS

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Physical Activity, Energetics and Metabolism (PAEM) research group

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